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ABSTRACT

This paper reviews recent summaries of research studies concerned with which indicator(s) best predict success in college chemistry. The conclusions of major studies and summaries are presented and the author's summary conclusions and recommendations are presented. The major findings/recommendations are that findings already completed be effectively synthesized and that ways for utilizing them in university advisement programs be established. (SL)

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A SUMMARY OF RESEARCH LITERATURE PREDICTING SUCCESS IN COLLEGE CHEMISTRY

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by

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PREDICTION OF SUCCESS IN FRESHMAN CHEMISTRY

For many years there has continued to be a concern about what best predicts success in college chemistry. Many college professors have belittled preparation in high school chemistry and others have praised it. Certainly, both the quality and the quantity of precollege science education has some relationship to success in college science courses. This paper discusses some of the findings from the literature relating to prediction of success in college chemistry.

A recent publication by Ogden summarizes 24 research studies relating to the question of whether success in high school chemistry relates to success in college chemistry. From these empirical studies completed between 1921 and 1967, Ogden draws the following conclusion:

> . . .there seems to be no magic answer. There is some indication that the taking of high school chemistry may be used as an indicator of success in college chemistry. There are indications that a math/physics background, high placement scores, achievement test scores, intelligence, and age may be better, or at least as good, as indicators. There is also evidence that no indicator is all that accurate. . .(Ogden, p. 125)

This writer agrees with the assessment of the references made by Ogden. There is evidence from the research studies that students who have taken high school chemistry do better in college chemistry though some of the references are to the contrary. However, there is no indication that the high school chemistry course is detrimental to the student in college chemistry. A number of studies relating to the general prediction question are summarized in the following pages.

Lindner studied 1225 students in first semester college chemistry at the University of Iowa. He concluded among other things that:

1. Sex is not a significant predictor.
2. Size of class was significant in two of the seven groups.
3. The ACT English and the ACT Natural Science scores were of no evident predictive value.
4. The ACT Mathematics score was a significant predictor in four of the groups. The ACT Composite was significant in three groups.
5. The ACT Social Studies score appeared as a significant predictor in the group which contained those students with the broadest backgrounds in science and mathematics.
6. Standing in class entered into five of the seven predictive equations.
7. Age at the time of enrollment in chemistry was involved in five of the seven equations.
8. Grades in high school courses are of considerably greater predictive value than number of semesters of the courses which were taken.[1]
(The F significance test was made at the 0.05 level.)
(Lindner, p. 1382B.

Lindner also notes that the greatest predicability, a multiple correlation of the 0.62, was found for students who had completed high school geometry, algebra, chemistry, physics and advanced mathematics. (Lindner, p. 1382-B)

Bajah studied freshman students at the University of South Dakota who were enrolled in chemistry. His conclusions were that:

1. The Percentile Rank of students in the graduating class had the highest correlation with achievement in freshman college chemistry.
2. The high school grade point average had a lower correlation with achievement in freshman college

chemistry than either high school mathematics grade or high school chemistry grade.

3. High school grade in mathematics had a slightly higher correlation with achievement in freshman college chemistry than did high school chemistry grade.

4. Of all the ACT scores, the Natural Science score had the lowest correlation with achievement in freshman college chemistry, while mathematics score had the highest correlation.

5. ACT Composite Score and the First Hour Examination score in chemistry combined are better predictors of achievement in freshman college chemistry than ACT Composite Score and high school Percentile Rank combined.[2]
(Hypotheses involving the use of correlation coefficients and t-Values were tested at the 0.05 alpha level of significance.)

Considerable similarity is reflected in the results from Bajah and Lindner.

Another study completed by Naibert at the State University of Iowa indicated that:

1. The most important single predictor of success obtained was the average of grades attained in all high school mathematics courses taken. This was significant at the one percent level of confidence.

2. New York State Regents Chemistry and Physics Examination Scores were found to be significant predictors of success in college chemistry at the one percent level of confidence.

3. Other variables found to be significant predictors at the five percent level of confidence in certain situations were:
   a) Preparation in a technical or non-technical high school
   b) Semesters of high school chemistry
   c) Semesters of high school physics
   d) Regents Biology Examination Score
   e) High School physics grade

4. Variables found to be insignificant at the five percent level were:

a) The number of semesters of high school mathematics
b) The number of semesters of high school science other than physics, chemistry or biology
c) The number of semesters of high school biology
d) High school rank in graduating class
e) Relative standing in graduating class
f) Size of graduating class
g) Regents average mathematics score
h) College Entrance Examination Board Mathematics Score
i) College Entrance Examination Board Verbal Score.

Naibert also determined that multiple correlations ranging from 0.56 to 0.68 were found between the multiple predictors; semesters of high school chemistry, average high school mathematics grade. Regents Chemistry Examination Score and Regents Physics Examination Score; and grade in college chemistry. This is consistent with the multiple correlation computed by Lindner though based on a different set of predictors. (Naibert, p.944)

Longmire of Rutgers University studied 120 college chemistry students to provide answers to the following questions:

> What relationships exist between performance in general college chemistry and a) completion of a course in secondary school chemistry, b) preparation in secondary school mathematics, c) secondary school preparation in sciences other than chemistry, d) location of residence (urban and rural), e) annual family income, f) parental education level, g)ACT scores in Natural Science, and h) ACT Composite scores? (Longmire,p.4028A)

He reached the following conclusions:

1. There was no statistically significant influence on the grade point average achieved in general college chemistry and a) completion of a course in secondary school chemistry, (b) secondary school preparation in sciences other than chemistry, (c) location of students' residence, (d) annual family income, (e) parental educational level, and (f) ACT scores (natural science and composite).

2. There was a statistically significant relationship between preparation in secondary school mathematics

> and grade point average in general college chemistry. Thus, the best single indicator of performance in general college chemistry, as a result of this study, is preparation in secondary school Mathematics. (Longmire, p. 2028A)

The conclusions drawn by Longmire contradict some studies in education in a number of the variables such as parental educational level and ACT Composite scores.

The study conducted by Scott from the University of Arkansas also indicates the importance of high school mathematics in achieving success in college general chemistry, and offers more indepth conclusions. His sample consisted of 1095 students, and the intercorrelations were established with 95 percent confidence limits. His findings are as follows:

> The number of units of mathematics or science taken in high school has little value as a predictor of success in any college science or mathematics. This high school variable can, however, be used to accurately predict the percentage of students that will make a C grade or higher in college science and mathematics.
>
> The grades received in high school general mathematics, alegebra I, algebra II, geometry, and advanced mathematics are good predictors of success in college science and mathematics, except for geology and physical science. The predictive value of these grades is greater for the freshman level than for the senior level.
>
> The average grade received in all mathematics taken in high school is a good predictor of success in college science and mathematics. In general, students who have made an A average in all high school mathematics tend to make an A or a B average in college science and mathematics, while those making a B or a C average in high school mathematics tend to make a C average in college science and mathematics.
>
> In general, grades received in high school science and mathematics are usable predictors of success in college science and mathematics. (Scott, p. 639A)

Rider of the University of Iowa found students with

background in high school chemistry did not perform better in college chemistry achievement than students who had not completed the high school course. (Rider, p.282A)

Williams and Lafferty offered these conclusions from their study at East Texas State College.

> ...A course in chemistry at the secondary school level appears to be definitely an aid to students who enroll in the beginning chemistry course in college. Apparently there is sufficient carry-over so that the student is assisted somewhat even when confronted with topics offered casually, or not at all, in the high school course...(Williams and Lafferty, P. 216)

Hendricks and others studied 643 chemistry students at the University of Georgia and determined that:

1. College students with or without credit in high school chemistry and without credit in advanced mathematics showed relatively equal achievement in first quarter college chemistry.

2. College students having credit in advanced mathematics courses from high school but without credit in high school chemistry showed significantly greater achievement in college chemistry than those without such credit.

3. College students with high school credits in both advanced mathematics and chemistry showed significantsly greater achievement than those without this combination of background courses.

4. College students with credit in high school physics and advanced mathematics but not chemistry achieved higher grades in college chemistry than those with credit in chemistry only.

5. Sex was not significant as a factor in achievement in college chemistry.

6. The influence of teacher-pupil ratio, high school size, and cost to the pupil for a high school education were not significant factors in determining possible success in college chemistry.

7. The best predictors of success in college chemistry work were a student's high school average and his achievement on the mathematical portion of the Scholastic Aptitude Test.(Hendricks and others, p.81)

Carlin compared two groups of 400 students each divided on the basis of whether they had completed high school chemistry. He found that students who had completed high school chemistry performed better than those who had not but that those who had completed both chemistry and physics at the high school level were best prepared. (Carlin, p. 26)

A multiple correlation of only 0.40 was computed by Kunhart and others for 111 introductory chemistry students at the junior college level. This was based on the combination of predictor results from grades in high school chemistry, high school algebra and the ACE scholastic aptitude scores in quantitative, linguistic and overall total. (Kunhart and others, p. 391) This is considerably smaller than multiple correlations derived by Lindner, Naibert and other studies discussed below.

The ACS test scores of 996 students of Vanderbilt University were correlated with college chemistry grades. The correlation for the total test was 0.54 as compared to the 0.36 correlation between college chemistry grades and the SAT mathematics scores. High school average correlated with college chemistry grades at 0.41. The multiple percent predictability utilizing the ACS, SAT and High School Average was approximately 40% (equivalent to a multiple correlation of over 0.60). (Sieveking and Savitsky, p. 374-376)

Two studies completed at Tennessee Technological University

by Collins and Gray resulted in multiple correlations of 0.65 and 0.68. In the study by Collins 481 students who completed the final examination in Chemistry 111, the more advanced of the freshman chemistry sequences, completed a questionnaire which provided information on their previous school backgrounds at the high school level. Scores from the ACT subtests in English, mathematics, social science and natural science; composite ACT scores; and high school averages were utilized in developing a regression equation for predicting final first quarter grades in chemistry. The analysis provided a multiple correlation of 0.65 with the ACT composite score providing the greatest single correlation of 0.58. The addition of the high school average and the ACT math subtest provided the remaining partial correlation and the other predictors were of insignificant value to the prediction equation. (Collins, p.6)

Additional comparisons made by Collins indicated that the addition of the high school grade in physics and chemistry added only 3% and 6% respectively to the prediction equation since the ACT composite score still accounted for most of the predictability. Comparisons were made between students who had completed high school chemistry and those who had not. The results indicated that the mean grade point average in college chemistry was only 1.43 for those who had not completed the high school chemistry course and 2.04 for those who had, highly statistically significant at the 0.001 level. Analysis of covariance results were calculated between the groups with the ACT composite and high school averages covaried. The results

were still statistically significant at the 0.01 level indicating that having completed the high school chemistry course was still a significant predictor of success in college chemistry. Students who had completed more years of high school mathematics did significantly better in college chemistry. However, when analysis of covariance was computed it was determined that this variable produced no significance not accounted for by the higher ACT scores associated with students who had better mathematics backgrounds. It was also determined that completion of high school physics remained a statistically significant predictor even though ACT scores and high school average were covaried in the test. (Collins, pp. 8-12)

As indicated above, Gray calculated a multiple correlation of 0.68 between two predictors; the ACT composite scores and high school physics grades and the grades in chemistry at Tennessee Tech. His study was based on a random sample of 150 students who were selected from the over 700 students enrolled in Chemistry 111 in the Fall Quarter of 1976. Of these students it was determined that 26 had completed a full sequence of both high school science and mathematics. Most of the multiple correlation was due to the ACT composite score which correlated at 0.66 with final grades in chemistry. The multiple correlation varied very little when the computation was based on the 138 students who had received grades for the course. Comparisons were made to determine whether sex of the student, enrollment in high school chemistry, enrollment in high school physics, enrollment in high school algebraII and enrollment in high

school senior mathematics were significant predictors of success in college chemistry. The results indicated that each of these was statistically significant except sex of the student. However, when analysis of covariance was computed it was determined that statistical significance was found in only one comparison, those who had completed senior mathematics did significantly better than those who had not enrolled in the course.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The results from studies completed over a number of years reveal that a number of findings have occurred in almost every study. The most evident finding is that students who have completed the full mathematics sequence and the full science sequence have been significantly more successful in college chemistry than those who have not. Interestingly, these same students generally score higher on national standardized tests such as the ACT and the SAT, they have higher overall grade point averages in high school as well as higher intelligence quotients. However, there seems to be sufficient consistency in the findings to indicate that students with equivalent scores on aptitude measures but who have not completed courses in high school physics, chemistry and mathematics do not perform as well. These findings are based on group predictions and are not necessarily applicable to individual cases.

The multiple correlations for predictors of success in college chemistry have generally fallen around the 0.60 level for most studies. Most often the best single predictor is the

ACT composite score or some other national aptitude measure. High school grade point average is usually found to be somewhere in the same range of value just behind the ACT composite. Individual grades in subjects such as high school mathematics, chemistry or physics generally correlate similarly to overall quality point average in high school and do not add an appreciably unique amount of predictability to regression equations. Considering the multiple correlation coefficient of 0.60 one can predict college chemistry grades accurately in approximately 36% of the cases and can determine the probability of success within a range of plus or minus one letter grade in the majority of cases.

One can conclude from the investigations reviewed that students have a poor success rate in college chemistry courses and that there is apparently little formal counseling offered in view of the amount of information shown from research studies. It appears that the major effort needed in this area of study is to effectively synthesize the findings which have already been completed and to establish ways for utilizing them in university advisement programs.

It is strongly recommended that high school counselors advise students who aspire to major in areas of study which require college chemistry to enroll in as many high school science and mathematics courses as possible. Background in high school chemistry, physics and advanced mathematics seem to be most effective predictors of success in college chemistry when mastered by students. The avoidance of these courses at the high school level considerably reduces the probability of success in chemistry at the college level.

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